The U-Tube: An Innovative Method for Collecting and Analyzing Deep-Well Samples

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RESEARCH OBJECTIVES

A novel sampling system, called a "U-tube," was deployed at the Frio Project site (Dayton, Texas) to collect and analyze multiphase fluids from a 1.5 km deep well during a CO_2 injection experiment, performed on a brine-saturated reservoir. Collection of representative fluid samples from deep reservoirs is challenging, because samples undergo depressurization and can be contaminated when brought to the land surface, causing changes in fluid chemistry, physical properties, and exsolution of dissolved gases. Project-specific goals also required high-frequency sample collection to capture CO_2 breakthrough and to characterize rapidly changing brine-CO_2 saturations during injection. High-quality samples and fluid saturation measurements provide insight into geochemical and hydrologic processes affecting sequestration of greenhouse gases (including CO_2) in deep geologic formations.

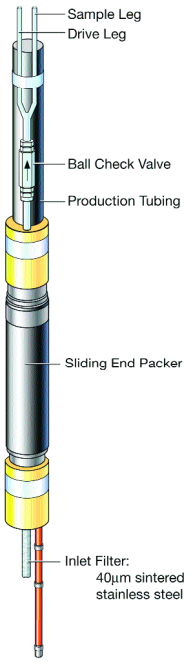

Figure 1. U-Tube sampling system

APPROACH

The U-tube sampling system consists of a continuous loop of steel tubing that starts and ends at land surface and is strapped to the outside of standard oil-field production tubing lowered into the well (Figure 1). The bottom of the U-tube is installed above the perforated production (sampling) interval and an inflatable packer. The packer isolates the interval from the upper part of the well, thus minimizing the volume purged during sample collection. A check valve connected to the bottom of the U, located immediately above the packer, controls the movement of fluid from the production interval into the U-tube. A short tube passing through the packer connects the U-tube through a filter to the production interval. The filter allows formation water to enter the U-tube, but prevents debris from clogging the valve. Operation of the U-tube is relatively simple. Compressed nitrogen gas is injected into the "drive leg" of the U-tube, closing the downhole check valve and forcing a slug of fluid to the surface via the "sample leg."

ACCOMPLISHMENTS

While the basic premise underlying the U-tube is not new, the system is unique because careful attention was given to processing the recovered two-phase samples. Strain gages mounted beneath high-pressure sample vessels at the surface measure the ratio of recovered brine to supercritical CO_2, providing gas-brine densities at reservoir conditions. A quadrupole mass spectrometer provided real-time gas analyses, allowing measurement of CO_2 and tracer breakthrough, and providing information on CO_2 saturations.

SIGNIFICANCE OF FINDINGS

Conventional approaches for deep-well sampling use submersible pumps, gas lift, or surface-based wireline samplers. Submersible pumps and gas-lift techniques can degas and/or contaminate samples, thus compromising fluid chemistry and promoting phase separation. Wireline samplers take small, discrete, infrequent samples that have the potential to miss CO_2 breakthrough. In comparison, the U-tube sampling system can be used to collect frequent, representative samples at reservoir conditions. In addition, it easily incorporates other program elements into its design, including bottomhole pressure and temperature measurements, and wireline logging through the center production tube.

RELATED PUBLICATIONS

Freifeld, B.M., C.A. Doughty, R.C. Trautz, S. Hovorka, L.R. Myer, and S.M. Benson, The Frio Brine Pilot CO_2 Sequestration Test—Comparison of field data and predicted results. Chapman Conference on the Science and Technology of Carbon Sequestration, San Diego, California, January 16–20, 2005. Berkeley Lab Report LBNL-56649.

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